SUPPLEMENT

TO BRITISH TELECOMMUNICATIONS ENGINEERING

(formerly the Supplement to The Post Office Electrical Engineers' Journal)

Vol. 4 Part 1 April 1985

ISSN 0262-4028

BTEC
GUIDANCE FOR STUDENTS

Contents

BTEC: MICRO-ELECTRONIC SYSTEMS I 1
BTEC: DIGITAL TECHNIQUES II 5
BTEC: RADIO II 9
BTEC: LINES II 12

BUSINESS AND TECHNICIAN EDUCATION COUNCIL

National Certificate in Telecommunications

Sets of model questions and answers for Business and Technician Education Council (BTEC) units are given below. The questions illustrate the types of questions that students may encounter, and are useful as practice material for the skills learned during the course.

Where additional text is given for educational purposes, it is shown within square brackets to distinguish it from information expected of students under examination conditions. Representative time limits for questions are shown, and care has been taken to give model answers that reflect these limits.

We would like to emphasise that the questions are not representative of questions set by any particular college.

BTEC: MICRO-ELECTRONIC SYSTEMS I

The questions in this paper are based on the BTEC's standard unit U79/602. Students are advised to read the notes above

Questions 1–16 are multiple-choice questions. For each question, students are required to indicate which of the four alternatives, (*a*), (*b*), (*c*) or (*d*), correctly answers the question or correctly completes the unfinished statement given. Approximately 1½ minutes should be allowed for each of these questions.

Q1 A system can be defined as an orderly arrangement of physical or abstract objects having inputs and outputs. Which one of the following is an example of a system?

(*a*) *an amplifier*
(*b*) *a resistor*
(*c*) *a storage capacitor*
(*d*) *an iron-cored smoothing coil*

A1 (*a*) an amplifier

[*Tutorial note:* An amplifier has signal inputs and outputs.]

Q2 An opto-isolator is a system that...

(*a*) *consists of a photo-electric transducer having an optical input and an electrical output.*
(*b*) *has no direct electrical connection between its input and output.*
(*c*) *must have its inputs and outputs connected to circuits having nearly the same electrical potentials.*
(*d*) *consists of two photo-electric transducers coupled so that an optical input gives an optical output at a different wavelength.*

A2 (*b*) has no direct electrical connection between its input and output.

[*Tutorial note:* The primary function of an opto-isolator is to provide electrical isolation between a signal input circuit and a signal output circuit.]

Q3 A system that is capable of converting signal energy from one form to another is called...

(*a*) *an amplifier.*
(*b*) *a function generator.*
(*c*) *a controller.*
(*d*) *a transducer.*

A3 (*d*) a transducer.

Q4 Which of the following is most likely to be classified as a transducer?

(*a*) *a fluorescent lamp*
(*b*) *a thermocouple*
(*c*) *an electrical motor*
(*d*) *an electrical immersion heater*

A4 (*b*) a thermocouple

[*Tutorial note:* The others are energy converters but not of signal energy.]

Q5 A thermistor is a device which responds to...

(*a*) *changes of pressure.*
(*b*) *changes of light level.*
(*c*) *changes of resistance.*
(*d*) *changes of temperature.*

A5 (*d*) changes of temperature.

Q6 The controller of a system is a device whose primary function is...

(*a*) *to enable the operator to control the inputs to a system.*
(*b*) *to enable the operator to have control over all the processes of a system at all times.*
(*c*) *to control and regulate the power supplies to a system.*
(*d*) *to control the overall system by initiating stored instructions in a predefined sequence.*

A6 (*d*) to control the overall system by initiating stored instructions in a predefined sequence.

[*Tutorial note:* The controller operates by means of a sequence of built-in, stored or user-programmed instructions in order to control the events and processes taking place in the system. It does not necessarily regulate the power to the system, give control to the operator at all times or necessarily give the operator control over the inputs.]

Q7 The characteristic shown in Fig. 1 is that of...

(*a*) *a negative-temperature-coefficient thermistor.*
(*b*) *a platinum resistance thermometer.*
(*c*) *a positive-temperature-coefficient resistance.*
(*d*) *a thermocouple thermometer.*

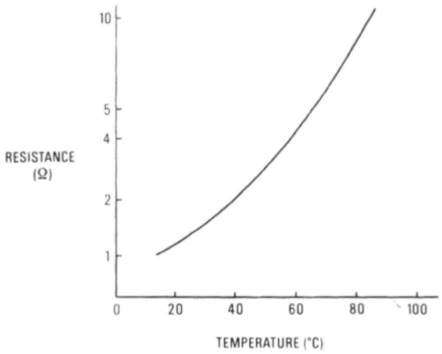


Fig. 1

A7 (*c*) positive-temperature-coefficient resistance.

Q8 In a micro-electronic control system, the set of stored instructions...

(*a*) *is always stored in random-access memory.*
(*b*) *is called an algorithm.*
(*c*) *is called a program.*
(*d*) *must always be contained within the system.*

A8 (*c*) is called a program.

[*Tutorial note:* A program may be stored anywhere within or outside the system. An algorithm is a description of a program written in general terms as opposed to a series of instructions.]

Q9 Micro-electronic process controllers use firmware because...

(*a*) *many of the control programs are used very many times without alteration.*
(*b*) *it is often necessary for the user to be able to modify control programs.*
(*c*) *the memory used is volatile.*
(*d*) *firmware is easier to develop than software.*

A9 (*a*) many of the control programs are used very many times without alteration.

[*Tutorial note:* Controllers performing the same functions repeatedly have their programs built-in; that is, as firmware.]

Q10 A flow chart is a diagram showing...

(*a*) *the flow of information through a system.*
(*b*) *the flow of inputs and outputs to and from a system.*
(*c*) *how the sequence of events of a program follows from one to the next.*
(*d*) *the structure of a program in terms of input and output data flows.*

A10 (*c*) how the sequence of events of a program follows from one to the next.

Q11 A digital signal...

(*a*) *has an infinite number of different values between two fixed limits.*
(*b*) *changes abruptly between a fixed number of nominal values.*
(*c*) *has two values only.*
(*d*) *changes smoothly between two values.*

A11 (*b*) changes abruptly between a fixed number of nominal values.

[*Tutorial note:* A digital signal need not necessarily have only two states.]

Q12 Which of the following is an example of a hybrid analogue–digital system with a digital output display?

(*a*) *an electronic pocket calculator*
(*b*) *a moving-coil voltmeter*
(*c*) *a digital voltmeter*
(*d*) *a digital counter*

A12 (*c*) a digital voltmeter

[*Tutorial note:* A digital voltmeter has analogue inputs and a digital display.]

Q13 Which one of the following relates to a purely analogue system?

(*a*) *Digital to analogue converters are necessary.*
(*b*) *Analogue to digital converters are necessary.*
(*c*) *Digital control processing is necessary.*
(*d*) *The input, output and process signals have waveforms that are continuously related to physical quantities.*

A13 (*d*) The input, output and process signals have waveforms that are continuously related to physical quantities.

Q14 The smallest unit of digital information is called...

(*a*) *a byte.*
(*b*) *a nibble.*
(*c*) *a bit.*
(*d*) *a word.*

A14 (*c*) a bit.

Q15 MSI integrated circuits are so called because...

(*a*) *they use metal-oxide silicon integration techniques.*
(*b*) *they use MOSFET technology.*
(*c*) *they contain between 10 and 100 circuit elements such as logic gates.*
(*d*) *all the circuit elements are contained in a single chip.*

A15 (*c*) they contain between 10 and 100 circuit elements such as logic gates.

[*Tutorial note:* MSI stands for *medium-scale integration.* Metal-oxide silicon is abbreviated to *MOS* as in *MOSFET*.]

Q16 A peripheral to a microcomputer...

(*a*) *is a device that is an essential part of the microprocessor.*
(*b*) *is a device that only sends data to the computer.*
(*c*) *must always be connected to the address bus of the computer.*
(*d*) *is usually connected to the computer via an input/output port.*

A16 (*d*) is usually connected to the computer via an input/output port.

[*Tutorial note:* A peripheral is an external device for sending data to the computer or receiving data from it. It is connected via an input/output port or sometimes directly to the data bus, but not necessarily to the address bus.]

Allow 6 min for each of the following questions.

Q17 State briefly the function of each of the following parts of a microcomputer:

(*a*) *the CPU,*
(*b*) *the ROM,*
(*c*) *the RAM, and*
(*d*) *the input/output unit.*

A17 (*a*) The function of the (CPU) (short for *central processing unit*) is to fetch instructions from an ordered sequence of addresses in memory and to execute these instructions in order to carry out data transfers and data manipulations, and to control the operation and timing of the other elements of a microcomputer system.

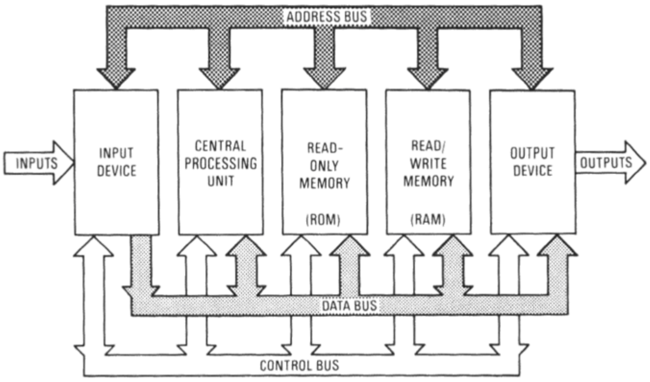
(*b*) The function of the ROM (short for *read-only memory*) is as an immediate and random-access read-only memory to provide permanent or semi-permanent non-volatile storage of programs and/or data that is built into a system as firmware.

(*c*) The function of the RAM (short for *random-access memory*) is as an immediate and random-access memory that has both read and write capabilities to provide temporary storage of user programs and/or data.

(*d*) The function of the input/output unit or units is to provide an interface and buffer between the internal data bus and control bus of the microcomputer, and the information and control signal paths to and from the peripherals that are connected to the microcomputer.

Q18 Draw a block diagram of a microcomputer consisting of a microprocessor, read-only memory (ROM), random-access memory (RAM), input port, output port, and the interconnecting information paths. Label each block and each information path clearly. Indicate the direction of flow of the information on each of the information paths.

A18



Q19 (a) State the three essential elements of a system.

(b) Briefly describe a thermostatically controlled electrical water-heating system in terms of its essential systems elements.

A19 (*a*) The three essential elements of a system are:

(*i*) inputs,
(*ii*) outputs, and
(*iii*) a process or processes by which the inputs are acted upon or processed in order to alter the outputs and/or the internal state of the system.

(*b*) (*i*) *Inputs* Cold water, electrical power, temperature of hot-water tank, temperature required (set or variable), time signals and on/off time settings if timer controlled, and manual on/off switch.

(*ii*) *Outputs* Hot water, on/off indication, time and time settings indication or display, set-temperature indication.

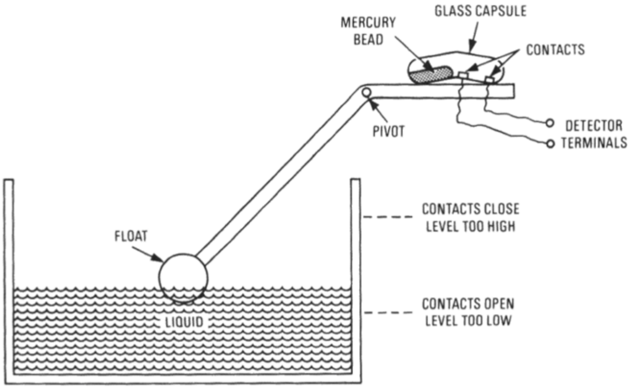
(*iii*) *Process* The electrical power to the immersion heating element is switched on or off, either manually or automatically, according to demand and according to whether or not the water temperature is lower than the required temperature.

Q20 (a) State THREE examples of electrical transducers that might be used to sense the temperature of a hot-water tank.

(b) Sketch a diagram showing how a mercury switch could be used as a liquid-level detector.

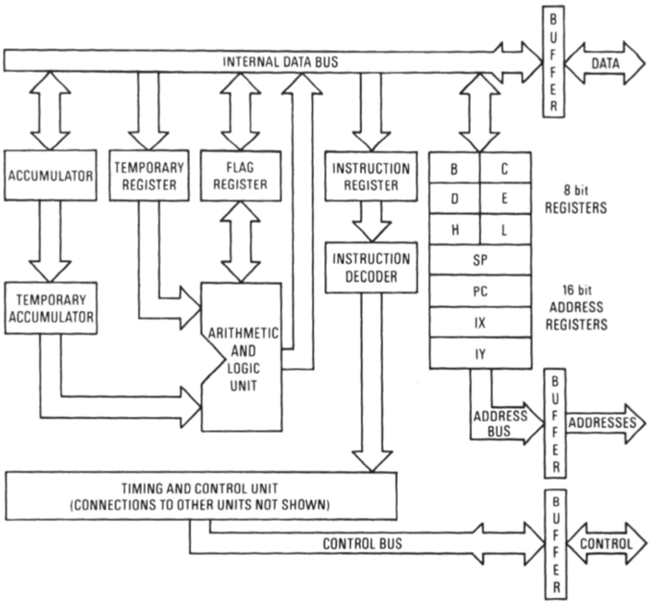
A20 (*a*) Bimetallic thermostat, thermistor, and resistance thermometer.

(*b*)



Q21 Sketch a block diagram showing the internal structure of a typical central processing unit (CPU).

A21



Q22 Give FOUR examples of typical microcomputer peripherals and state the basic function of each of them.

A22 (*a*) *Visual display unit* (*VDU*) To display data, programs, text, and other visual information output by the computer, and to 'echo' entries to the computer from the keyboard.

(*b*) *Keyboard* To enter data, programs, and commands on-line to the computer.

(*c*) *Magnetic floppy-disc unit* To provide back-up storage of data and programs.

(*d*) *Printer* To provide hard copy of computer outputs of data etc.

Q23 (a) What is meant by the 'program' of a microprocessor-controlled system?

(b) Why is a microprocessor-controlled system operated by means of a program?

A23 (*a*) A program is an ordered sequence of coded instructions used by the microprocessor to perform given functions or tasks. (The program is almost invariably stored in a sequence of addressed memory locations.)

(*b*) Although a typical microprocessor has a fairly large selection of different coded instructions (op-codes) that it can act upon (execute), each instruction code causes the microprocessor to perform only a very simple task. Thus, a sequence of several instructions—that is, a program—is required for the processor to carry out more complex tasks. (Usually, a very large number of instructions must be carried out in a short time; hence, the program is stored in an immediate, fast-access memory.)

Q24 Explain the following terms:

(*a*) *hardware,*
(*b*) *software, and*
(*c*) *firmware.*

A24 (*a*) Hardware consists of the physical components of a system, such as the integrated circuits, the circuit boards and the chassis.

(*b*) Software consists of the written programs of instructions and the associated data, whether stored in immediate-access random-access memory, in back-up memory or simply in written or printed form.

(*c*) Firmware consists of software that is permanently or semi-permanently stored in non-volatile read-only memory. Firmware is the software that is built into a system, such as control programs and executive programs that do not require to be readily changed.

Q25 Explain the terms 'volatile' and 'non-volatile' as applied to random-access memory.

A25 The contents of the memory cells of a volatile random-access memory (RAM) are lost when power to the system is interrupted or switched off. A non-volatile RAM is such that the memory contents are not lost when power is interrupted; this may be because the particular type of integrated circuit used is able to retain the information stored in it, or because there is a back-up system to save the contents of the memory when the power is off.

Q26 State the meaning of the standard flow chart symbols given in Fig. 2.

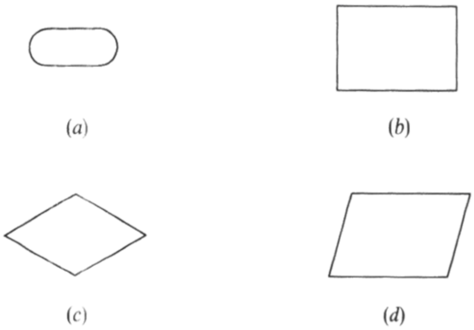
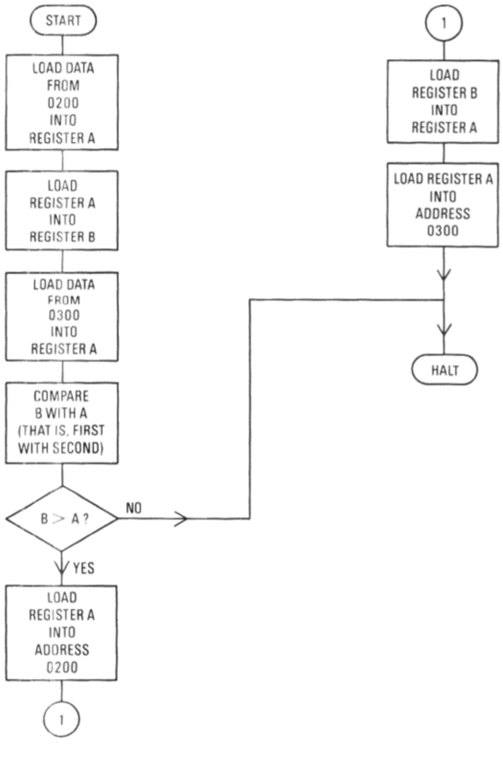


Fig. 2

A26 (*a*) Start or end (stop) of a program flow chart.
(*b*) Process or action in a program flow chart.
(*c*) Decision in a program flow chart.
(*d*) Input or output in a program flow chart.

Q27 Draw the flow chart of a program that compares a number stored in memory location 0200 with a second number at location 0300 and interchange the two if the first number is larger than the second. Use straightforward English rather than mnemonic codes.

A27


START
LOAD DATA FROM 0200 INTO REGISTER A
LOAD REGISTER A INTO REGISTER B
LOAD DATA FROM 0300 INTO REGISTER A
COMPARE B WITH A (THAT IS, FIRST WITH SECOND)
B > A ?
NO
YES
LOAD REGISTER A INTO ADDRESS 0200
1
1
LOAD REGISTER B INTO REGISTER A
LOAD REGISTER A INTO ADDRESS 0300
HALT

Q28 Most microprocessor instructions can be grouped into THREE *categories. State what these three categories are and briefly explain them.*

A28 (*a*) *Data Transfer Instructions* To transfer bytes or words of data between the registers of the central processing unit (CPU), between the registers and the accumulator, or between the registers or accumulator and memory.

(*b*) *Arithmetic and Logic Instructions* To perform arithmetical operations such as add, subtract etc. and logic operations such as shift, AND, OR etc. These operations involve the accumulator and the arithmetic and logic unit (ALU).

(*c*) *Test and Branch Instructions* To test various conditions such as whether or not certain pieces of data are zero or positive etc. (by using the *flag* register for example), and to transfer control to different parts of the program. These instructions facilitate conditional and unconditional jumps, branches and loops within a program.

Questions 29–32 inclusive are concerned with microprocessor programming in machine code and may use the instructions given in the following table.

[*Tutorial note:* This table is a selection taken from the Z80 instruction set. Students should expect that a similar selection could be taken from the instruction set of other types of microprocessor.]

Instruction	Hexadecimal Code	Mnemonic Code
Load register A with byte *n*	3E	LD A, *n*
Load register HL with 2 bytes *nn*	21	LD HL, *nn*
Load register A with the byte from address (HL)	7E	LD A, (HL)
Load register A with the byte from address (*nn*)	3A	LD A, (*nn*)
Load register B with the byte from address (HL)	46	LD B, (HL)
Load address (HL) from the register A	77	LD (HL), A
Load address (HL) from the register B	70	LD (HL), B
Load address (*nn*) from the register A	32	LD (*nn*), A
Add register B to register A	80	ADD A, B
Subtract register B from register A without carry	90	SUB B
Compare register B with register A and set the flag registers	B8	CP B
Increment register HL	23	INC HL
Decrement register HL	2B	DEC HL
Jump to address *nn*	C3	JP *nn*
Jump to address *nn* if *zero* flag is set	CA	JPZ *nn*
Jump to address *nn* if *zero* flag is not set	C2	JPNZ *nn*
Halt	76	HALT

Q29 Briefly explain the operation of the following program by outlining its corresponding algorithm.

Address	*Hexadecimal Code*	*Mnemonic*
0200	*210030*	*LD HL, 0300H*
0203	*7E*	*LD A, (HL)*
0204	*23*	*INC HL*
0205	*46*	*LD B, (HL)*
0206	*77*	*LD (HL), A*
0207	*2B*	*DEC HL*
0208	*70*	*LD (HL), B*
0209	*76*	*HALT*

Address 0300 contains FF. Call it DATA1.
Address 0301 contains 00. Call it DATA2.

A29 *Step 1* The store address register (HL) is loaded with the address of *DATA1*; that is, 0300.

Step 2 The data from the above address is loaded into the accumulator (register A).

Step 3 The address register (HL) is incremented by 1 to 'point' to the address of *DATA2*; that is, 0301.

Step 4 *DATA2* is loaded from address 0301 into register B.

Step 5 *DATA1* is stored from the accumulator into address 0301.

Step 6 The address register (HL) is decremented by 1 to 'point' to address 0300.

Step 7 *DATA2* is stored from register B into address 0300.

Step 8 Halt.

BTEC: MICRO-ELECTRONIC SYSTEMS I *(continued)*

Q30 Write a program in mnemonic code to compare a byte of data in location 0200 with a byte of data in location 0201, and then to store a byte 00 in location 0300 if the data in 0200 is equal to the data in 0201, but store FF if they are not equal.

A30

```
START:  LD HL, 0200H
        LD A, (HL)
        INC HL
        LD B, (HL)
        CP B
        JPZ ZERO; or some other label.
        LD A, FFH
        LD (0300H), A
        HALT
 ZERO:  LD A, 00H
        LD (0300), A
        HALT
```

Q31 What do each of the following registers and memory locations contain after the program given in Question 29 has been run

(a) the accumulator,
(b) register B,
(c) register HL,
(d) memory address 0300, and
(e) memory address 0301.

A31 (*a*) Register A contains FF.
(*b*) Register B contains 00.
(*c*) Register HL contains 0300.
(*d*) Address 0300 contains 00.
(*e*) Address 0301 contains FF.

Q32 Write a program in hexadecimal machine code to add the contents of location 0300 to the contents of location 0301 and store the result in location 0303. Assume that the result is not more than one byte. Start the program at address 0100.

A32

Address	Hexa-decimal Code	Mnemonic	Comments
0100	210003	LD HL, 0300H	Set memory pointer
0103	46	LD B, (HL)	Put first number in register B
0104	23	INC HL	Point to second number
0105	7E	LD A, (HL)	Put second number in register A
0106	80	ADD A, B	Add first number to second number in register A
0107	23	INC HL	Point to result address
0108	77	LD (HL), A	Store result
0109	76	HALT	

Questions and answers contributed by B. Evans

BTEC: DIGITAL TECHNIQUES II

The questions in this paper are based on the BTEC's standard unit U81/750. Students are advised to read the notes on p. 1

Q1 Which of the binary numbers given below is equivalent to the decimal number 177·781 25 and give your reasons:

(a) 01 111 110·111 100 1,
(b) 10 110 001·110 01,
(c) 10 001 101·100 11, or
(d) 1 101 100·111 01? (*5 min*)

A1 (*b*) 10 110 001·110 01

The solution is found by repeatedly dividing the integer part of the decimal number by 2, and then repeatedly multiplying the fractional part by 2, as shown in the following:

Integer Part

	Remainder	
2) 177		
2) 88	1	(least significant bit)
2) 44	0	
2) 22	0	
2) 11	0	
2) 5	1	
2) 2	1	
2) 1	0	
0	1	(most significant bit)

Fractional Part

	Overflow	
		·781 25
		2 ×
(most significant bit)	1	·562 50
		2 ×
	1	·125 00
		2 ×
	0	·250 00
		2 ×
	0	·500 00
		2 ×
(least significant bit)	1	·000 00

Thus, 177·781 25 is equivalent to 10 110 001·110 01 in binary.

Q2 Write down the decimal equivalent of the following binary numbers:

(a) 1 100 001·1001, and
(b) 1 010 101. (*5 min*)

A2 [*Tutorial note:* The numbers can be converted to decimal by writing down the 'weight' of each bit and adding them together.]

(*a*) 1 100 001·1001

$$= (1 \times 64) + (1 \times 32) + (1 \times 1) + (1 \times 0{\cdot}5) + (1 \times 0{\cdot}0625),$$

$$= \underline{97{\cdot}5625}.$$

(*b*) 1 010 101

$$= (1 \times 64) + (1 \times 16) + (1 \times 4) + (1 \times 1),$$

$$= \underline{85}.$$

Q3 Convert the following decimal numbers to their binary equivalent by using signed two's complement notation:

(a) −250, and
(b) −7. (*6 min*)

A3 [*Tutorial note:* In signed two's complement notation the most significant bit of a number is taken to represent its sign, with the convention that 0 represents a positive sign and 1 represents a negative sign.]

(*a*) First convert +250 to binary.

	Remainder
2) 250	
2) 125	0
2) 62	1
2) 31	0
2) 15	1
2) 7	1
2) 3	1
2) 1	1
0	1

Thus, +250 is equivalent to 011 111 010 in binary, where the most significant bit represents the + sign.

The two's complement is found by inverting the number and adding 1.

Number: 011 111 010
Invert: 100 000 101
Add 1: 1
100 000 110

Thus, −250 is equivalent to 100 000 110 in binary.

(*b*) Convert +7 to binary.

	Remainder
2) 7	
2) 3	1
2) 1	1
0	1

Thus, +7 is equivalent to 0111 in binary.

The two's complement is found by inverting the number and adding 1.

Number: 0111
Invert: 1000
Add 1: 1
1001

Thus, −7 is equivalent to 1001 in binary.

Q4 *What are the one's complement and the two's complement of each of the following binary numbers:*

(*a*) *11 111 111,*
(*b*) *01 000 000, and*
(*c*) *10 101 010?* (*5 min*)

A4 [*Tutorial note:* The one's complement of a binary number is found by inverting each bit. The two's complement is found by adding 1 to the one's complement.]

(*a*)

Number:	11 111 111	
Invert:	00 000 000	One's complement
Add 1:	1	
	00 000 001	Two's complement

Thus, the one's complement is 00 000 000 and the two's complement is 00 000 001.

(*b*)

Number:	01 000 000	
Invert:	10 111 111	One's complement
Add 1:	1	
	11 000 000	Two's complement

Thus, the one's complement is 10 111 111 and the two's complement is 11 000 000.

(*c*)

Number:	10 101 010	
Invert:	01 010 101	One's complement
Add 1:	1	
	01 010 110	Two's complement

Thus, the one's complement is 01 010 101 and the two's complement is 01 010 110.

Q5 *Which of the numbers below represents the decimal equivalent of the sum of the binary numbers 1 010 111·110 and 100·0111:*

(*a*) *167·75,*
(*b*) *87·1850,*
(*c*) *101·125, or*
(*d*) *92·1875?*

Explain your choice. (*6 min*)

A5 (*d*) 92·1875

The two numbers can be added together as follows:

	1 010 111·110
	100·0111 +
Carry	1 1 1 1 1
Sum	1 011 100·0011

This is converted to decimal as follows:

1 011 100·0011

$$= (1 \times 64) + (1 \times 16) + (1 \times 8) + (1 \times 4)$$
$$+ (1 \times 0{\cdot}125) + (1 \times 0{\cdot}0625),$$
$$= 92{\cdot}1875.$$

Q6 *Perform the following calculations using complement addition. The numbers given are in the signed two's complement notation.*

(*a*) *01 110 111 − 00 010 100*
(*b*) *01 010 110 − 11 110 010* (*8 min*)

A6 (*a*) The one's complement of 00 010 100 is 11 101 011. Thus:

	01 110 111
Add complement:	11 101 011
Add 1:	1
	1 01 100 011

↑
Overflow

The overflow bit is ignored to give the result 01 100 011.

(*b*) The one's complement of 11 110 010 is 00 001 101. Thus:

	01 010 110
Add complement:	00 001 101
Add 1:	1
	01 100 100

The result is 01 100 100.

Q7 *Use a 'shift and add' method of multiplication to calculate the following products in binary:*

(*a*) *10 × 7, and*
(*b*) *15 × 16.*

Give the result in binary. (*7 min*)

A7 (*a*) Converting the numbers to binary first, the problem becomes:

1 010	Multiplicand
111	Multiplier
1 010	First partial product
1 010	Second partial product
11 110	Add
1 010	Third partial product
1 000 110	Product

The result in binary is 1 000 110.

(*b*)

1 111	Multiplicand
10 000	Multiplier
11 110 000	Product

The result in binary is 11 110 000

[*Tutorial note:* Multiplication by 16 is equivalent to shifting the multiplicand left by four bits.]

Q8 *What is the quotient and remainder when the following binary division is carried out:*

1 110 101 ÷ 110.

Confirm your result in decimal. (*4 min*)

A8

10 011
110)1 110 101
1 10
0 010 10
1 10
1 001
1 10
0 011

Thus 1 110 101 ÷ 110 = 10 011 remainder 011.

In decimal, 1 110 101 = 117,
110 = 6,
1 011 = 19, and
011 = 3.

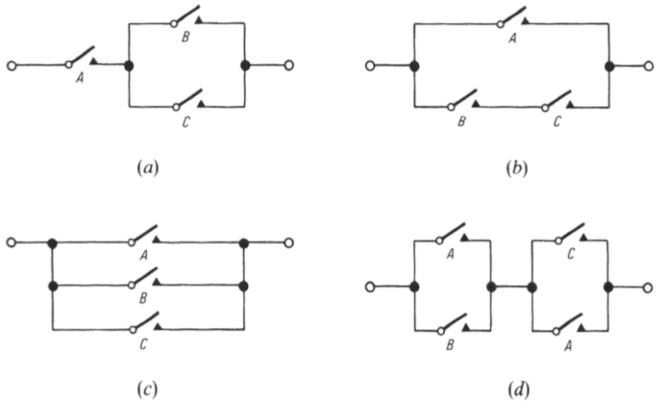
Thus 117 ÷ 6 = 19 remainder 3, which is correct.

Q9 *Draw a truth table to illustrate the statement: The output of a circuit, D, is at logic 1 whenever more than one of its inputs A, B and C are at logic 1.* (*2 min*)

A9

A	B	C	D
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Q10 *Which of the circuits shown in Fig. 1 are equivalent?* *(4 min)*



(*a*) (*b*)

(*c*) (*d*)

Fig. 1

A10 Circuits (*b*) and (*d*) are equivalent since their Boolean expressions can be written as:

(*b*) $A + B \,.\, C$, and
(*d*) $(A + B) \,.\, (A + C)$,

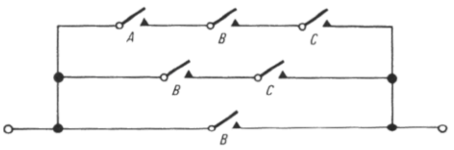
which are equivalent.

Q11 *Construct a switch circuit which is represented by the Boolean expression*

$$(A \,.\, B \,.\, C) + (B \,.\, C) + B,$$

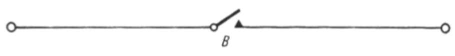
and hence deduce a simplified circuit. *(4 min)*

A11 The switch circuit is shown in sketch (*a*).



(*a*)

However, since B is common to all branches of the circuit, it may be reduced to the circuit shown in sketch (*b*).



(*b*)

Q12 *Complete the following expressions, which represent the laws of Boolean algebra.*

(*a*) $A + 0 =$
(*b*) $B \,.\, 0 =$
(*c*) $\bar{C} \,.\, C =$
(*d*) $D + \bar{D} =$
(*e*) $E \,.\, F =$ *(3 min)*

A12 (*a*) $A + 0 = A$
(*b*) $B \,.\, 0 = 0$
(*c*) $\bar{C} \,.\, C = 0$
(*d*) $D + \bar{D} = 1$
(*e*) $E \,.\, F = F \,.\, E$

Q13 *Write down the Boolean expression and, hence, derive the truth table for the switch circuit shown in Fig. 2.* *(6 min)*

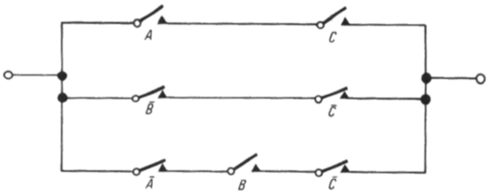


Fig. 2

A13 The top branch of the circuit is represented by $A \,.\, C$.
The second branch is represented by $\bar{B} \,.\, \bar{C}$.
The bottom branch is represented by $\bar{A} \,.\, B \,.\, \bar{C}$.
Thus the complete Boolean expression becomes

$$A \,.\, C + \bar{B} \,.\, \bar{C} + \bar{A} \,.\, B \,.\, \bar{C}$$

The truth table can therefore be constructed as shown below.

A	B	C	Output
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

Q14 *Derive the Boolean expression for the switch circuit shown in Fig. 3 and, hence, produce a simplified switch circuit which will perform in the same way.* *(6 min)*

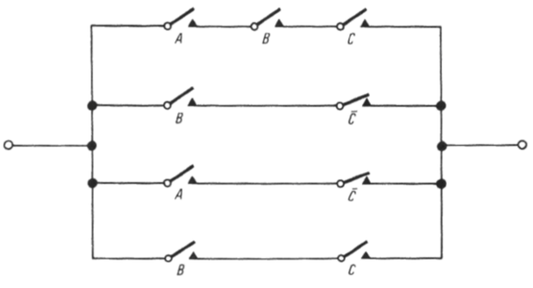


Fig. 3

A14 The branches of the circuit can be considered individually.

Top branch ...	$A \,.\, B \,.\, C$
Second branch ...	$B \,.\, \bar{C}$
Third branch ...	$A \,.\, \bar{C}$
Bottom branch ...	$B \,.\, C$

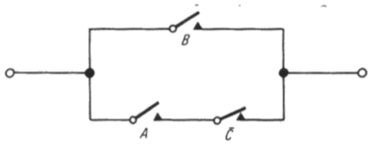
Thus the complete expression becomes

$$A \,.\, B \,.\, C + B \,.\, \bar{C} + A \,.\, \bar{C} + B \,.\, C.$$

Simplifying the expression gives

$$B \,.\, \bar{C} + A \,.\, \bar{C} + B \,.\, C \qquad (A \,.\, B \,.\, C \text{ redundant})$$
$$= B \,.\, (\bar{C} + C) + A \,.\, \bar{C}, \quad \text{(collecting terms)}$$
$$= B + A \,.\, \bar{C}. \quad (\bar{C} + C = 1)$$

Thus the simplified switch circuit is as shown in the sketch.



Q15 *Draw a switch circuit that satisfies the outputs specified in the truth table below after the expression has been simplified.*

A	*B*	*C*	*Output*
0	*0*	*0*	*1*
0	*0*	*1*	*0*
0	*1*	*0*	*1*
0	*1*	*1*	*0*
1	*0*	*0*	*1*
1	*0*	*1*	*1*
1	*1*	*0*	*1*
1	*1*	*1*	*1*

(7 min)

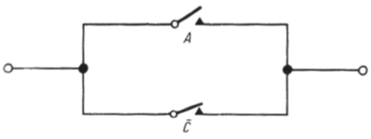
A15 The expression derived from the truth table is

$$\bar{A}\,.\,\bar{B}\,.\,\bar{C} + \bar{A}\,.\,B\,.\,\bar{C} + A\,.\,\bar{B}\,.\,\bar{C} + A\,.\,\bar{B}\,.\,C + A\,.\,B\,.\,\bar{C} + A\,.\,B\,.\,C.$$

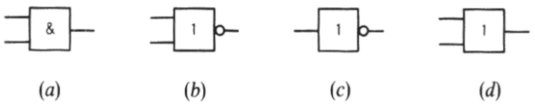
This can be simplified to

$$\begin{aligned} & A\,.\,(\bar{B}\,.\,\bar{C} + \bar{B}\,.\,C + B\,.\,\bar{C} + B\,.\,C) + \bar{C}\,.\,(\bar{A}\,.\,\bar{B} + \bar{A}\,.\,B), \\ &= A\,.\,(\bar{B}\,.\,(\bar{C} + C) + B\,.\,(\bar{C} + C)) + \bar{C}\,.\,(\bar{A}\,.\,(\bar{B} + B)), \\ &= A\,.\,(\bar{B} + B) + \bar{C}\,.\,(\bar{A}), \\ &= A + \bar{A}\,.\,\bar{C}, \\ &= A + \bar{C}. \end{aligned}$$

Thus the simplified switch network is as shown in the sketch.



Q16 *Name the logic element indicated by each of the symbols shown in Fig. 4.* *(2 min)*



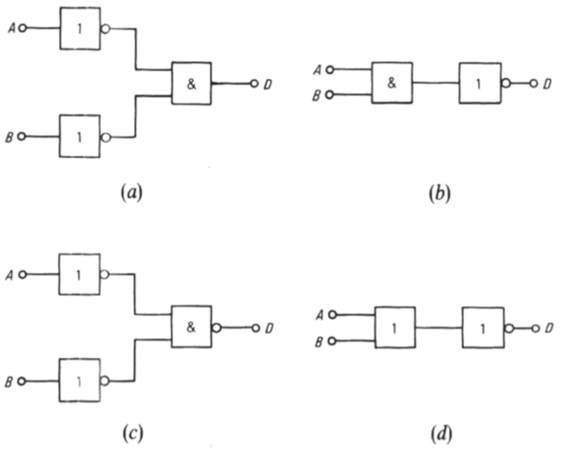
(*a*) (*b*) (*c*) (*d*)

Fig. 4

A16 The symbols shown are:

(*a*) AND,
(*b*) NOR,
(*c*) NOT, and
(*d*) OR.

Q17 *Which of the circuits shown in Fig. 5 are equivalent, and why?* *(3 min)*



(*a*) (*b*)
(*c*) (*d*)

Fig. 5

A17 Circuits (*a*) and (*d*) produce the same output and are therefore equivalent. Their truth table is shown below.

A	*B*	*D*
0	0	1
0	1	0
1	0	0
1	1	0

Q18 *Derive the truth table for the logic circuit shown in Fig. 6.* *(5 min)*

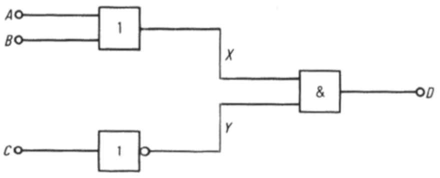


Fig. 6

A18 The truth table can be produced simply from a Boolean expression for the circuit, as follows.

$$X = A + B,$$

$$Y = \bar{C},$$

Thus $$D = (A + B)\,.\,\bar{C}$$

The truth table is as follows.

A	*B*	*C*	*D*
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Q19 *A simple binary adding circuit produces a logic 1 at its output if either of its inputs A and B are at logic 1, but not if both of them are at logic 1. Draw a suitable circuit using only* AND, OR *or* NOT *gates.* *(5 min)*

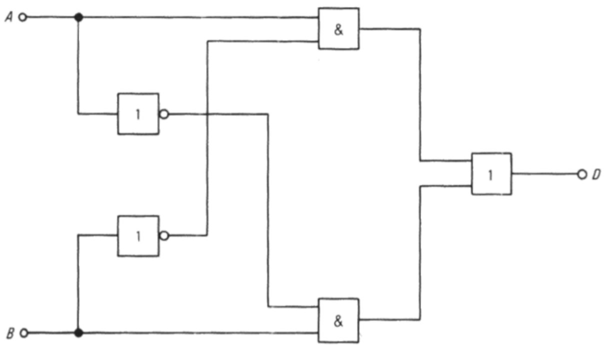
A19 The circuit produces an output according to the following truth table.

A	*B*	*D*
0	0	0
0	1	1
1	0	1
1	1	0

Thus, a suitable Boolean expression is

$$D = A\,.\,\bar{B} + \bar{A}\,.\,B.$$

The circuit is shown in the sketch.



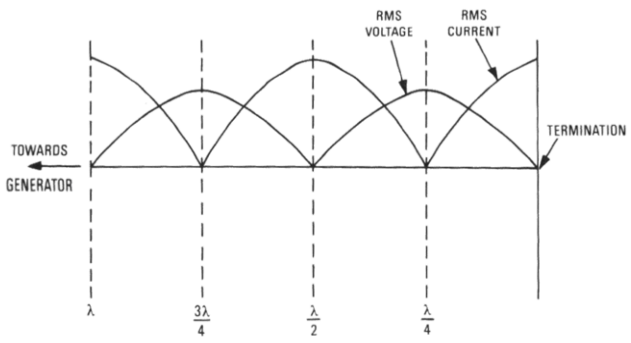
Questions and answers contributed by D. Turner

BTEC: RADIO II

The questions in this paper are based on the BTEC's standard syllabus U81/754. Students are advised to read the notes on p. 1

Q1 *Sketch the curves of voltage and current standing waves for a line λ long which is short circuited (λ is the wavelength).* (*8 min*)

A1



Q2 *Referring to loss-free lines, indicate whether the following are true or false.*

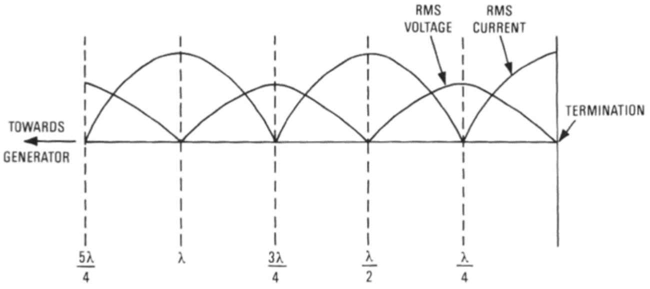
(*a*) *The input impedance to a 5λ/4-long short-circuited line is zero. TRUE/FALSE.*

(*b*) *The input impedance to a 5λ/4-long short-circuited line is infinite. TRUE/FALSE.*

(*c*) *The input impedance to a 5λ/4-long short-circuited line is equal to its characteristic impedance. TRUE/FALSE.* (*6 min*)

A2 (*a*) False.

(*b*) True. [*Tutorial note:* It can be seen from the sketch that, at 5λ/4, the RMS voltage is a maximum and the RMS current is a minimum.]



(*c*) False.

Q3 *Referring to loss-free lines, indicate whether the following are true or false.*

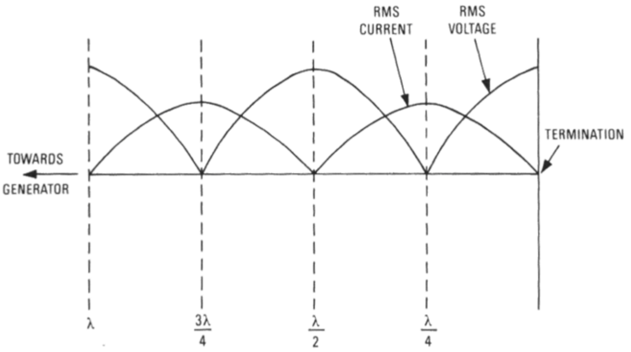
(*a*) *The input impedance to a λ-long open-circuited line is zero. TRUE/FALSE.*

(*b*) *The input impedance to a λ-long open-circuited line is infinite. TRUE/FALSE.*

(*c*) *The input impedance to a λ-long open-circuited line is equal to its characteristic impedance. TRUE/FALSE.* (*5 min*)

A3 (*a*) False.

(*b*) True. [*Tutorial note:* It can be seen from the sketch that, at λ, the RMS voltage is a maximum and the RMS current is a minimum.]

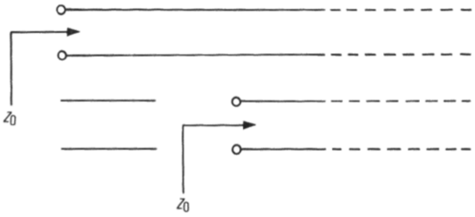


(*c*) False.

Q4 (*a*) *Briefly explain the term 'characteristic impedance' of a radio-frequency transmission line.*

(*b*) *Calculate the characteristic impedance, Z_0, of the line if the input impedances when the line is open circuit and short circuit are 62·5 Ω and 40 Ω, respectively.* (*8 min*)

A4 (*a*) Consider a transmission line which is uniform throughout its length and which extends infinitely in one direction; then break the line and consider the electrical properties of the remaining infinitely long part, as shown in the sketch. The input impedance of the line is the same no matter where the break is made. This impedance, Z_0, is known as the *characteristic impedance* of the transmission line.



(*b*) It can be shown that:

$$Z_0 = \sqrt{(Z_{oc} \times Z_{sc})},$$

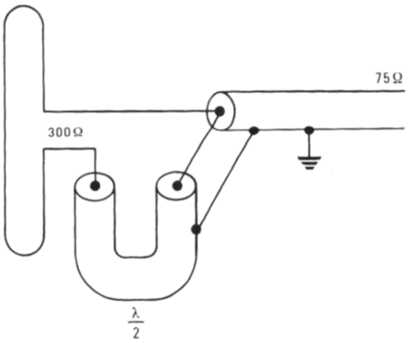
where Z_{oc} and Z_{sc} are the open-circuit and short-circuit input impedances, respectively.

$$\therefore \quad Z_0 = \sqrt{(62{\cdot}5 \times 40)}, = \sqrt{2500} = \underline{50\,\Omega.}$$

Q5 *With the aid of a sketch, describe a balun transformer and its use. (A mathematical answer is not required.)* (*8 min*)

A5 The balance-unbalance transformer, commonly called a *balun*, enables a balanced circuit to be coupled to an unbalanced circuit and vice versa.

In most cases, an aerial requires a balanced feed with respect to ground, and, therefore, when it has to be coupled to a coaxial cable that has an unbalanced output, a balun could be used. The sketch shows a folded dipole with a λ/2 balun.



Q6 (*a*) *Briefly explain the difference between ground waves and sky waves, and state their typical uses.*

(*b*) *With the aid of a sketch, explain the following terms used in radio communication:*

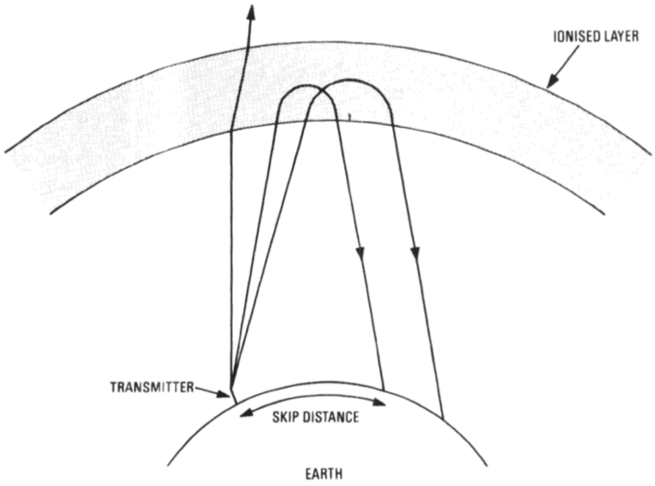
(*i*) *skip distance, and*
(*ii*) *maximum usable frequency (MUF).* (*8 min*)

A6 (*a*) The radiated energy from a transmitting aerial may reach the receiving aerial by one or more modes of propagation. The radiated signal which reaches the receiver after travelling along the earth's surface is called a *ground wave.* The *sky wave*, on the other hand, is the radiated signal which reaches the receiver after being reflected back to earth from the ionosphere.

Typical uses are:

(*i*) *Ground Wave* Sound broadcasting in the medium waveband.
(*ii*) *Sky Wave* Long-distance telephony links.

(*b*) (*i*) The distance from the transmitter to the nearest point where a sky wave can be received is called the *skip distance* (see sketch).
(*ii*) Maximum usable frequency is the highest frequency that can be used to establish communication, by using sky waves, between two points on the earth's surface.



Q7 *Explain the following terms as applied to aerials:*

(*a*) *radiation resistance, and*
(*b*) *isotropic radiator.* (*6 min*)

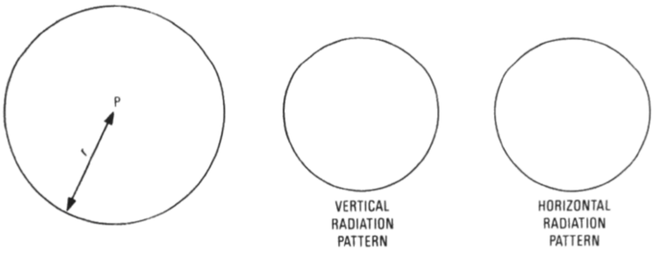
A7 (*a*) The radiation resistance of an aerial is that resistance which will absorb the same power as the aerial radiates.

If an aerial radiates a total power of P watts, for a driving current of I amps (RMS), and the radiation resistance is R_R ohms, then

$$P = I^2 R_R \text{ watts.}$$

[*Tutorial note:* The quantity cannot be measured by using an ohmmeter, but it does give a measure of the effectiveness of an aerial as a radiator of radio waves. A half-wave dipole has a resistance of approximately 73 Ω, measured at the centre.]

(*b*) An isotropic radiator cannot be realised in practice, but it provides a useful reference system. An isotropic radiator is a point source (P) that radiates equally in all directions, as shown in the sketch.



Q8 *Define*

(*a*) *the gain, and*
(*b*) *the effective radiated power* (*ERP*)

of an aerial. (*6 min*)

A8 (*a*) The gain, G, is defined as

$$G = \frac{\text{power radiated by aerial}}{\text{power radiated by reference aerial}},$$

in a particular direction, usually along the main lobe of the polar diagram, for the same input power to both aerials.

G can be expressed as a factor, but is more usually quoted in decibels.

[*Tutorial note:* Any aerial can be used as a reference; the most common references are:

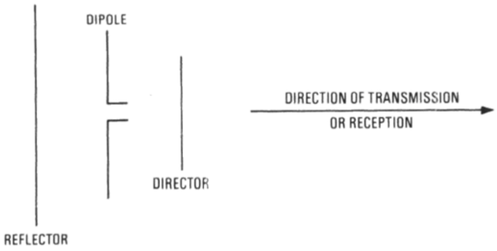
(*i*) the isotropic radiator, and
(*ii*) the half-wave dipole.]

(*b*) The effective radiated power (ERP) of an aerial is the power that an isotropic radiator would have to radiate to provide the same field strength at a particular point, usually along the main lobe of the polar diagram.

Q9 (*a*) *With the aid of a sketch, briefly explain the main purpose of using a director and a reflector in an aerial array.*
(*b*) *Sketch the horizontal polar diagram of*

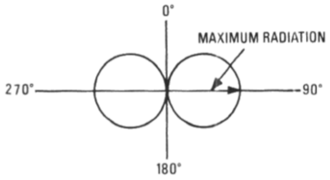
(*i*) *the dipole alone,*
(*ii*) *the dipole with a reflector, and*
(*iii*) *the dipole with a reflector and a director.* (*12 min*)

A9 (*a*) The main purpose of using a director and a reflector in an aerial array is to modify the radiation pattern of an aerial in order to concentrate the radiation in a particular direction. The aerial array is shown in sketch (*a*).

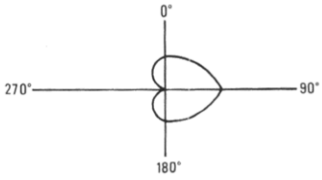


(*a*)

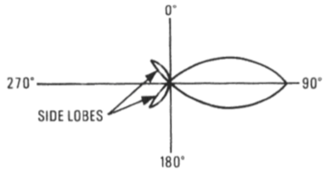
(*b*) (*i*) Sketch (*b*), a figure-of-eight polar diagram, applies only to the horizontal plane containing the dipole. The radiation, as can be seen from sketch (*b*), is concentrated at right angles to the dipole.
(*ii*) Sketch (*c*) shows a radiation pattern which has only one maximum at right angles to the dipole and away from the reflector.
(*iii*) Sketch (*d*) shows the improved forward response, which has higher gain and reduced beamwidth. The addition of more directors produces a narrower beam, but more than one director is usually used for very-high-frequency (VHF) transmission, where eight or nine directors may be used.



(*b*)



(*c*)



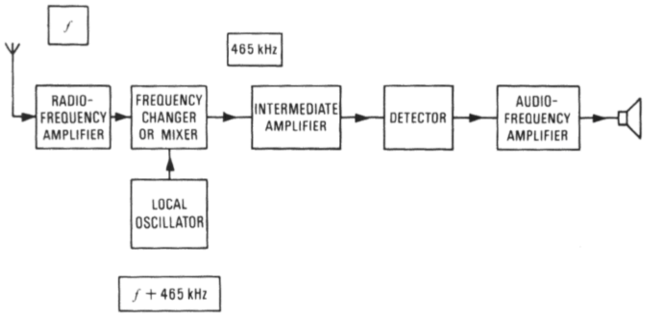
(*d*)

Q10 *List* FOUR *main factors to be taken into account in choosing the intermediate frequency for a superheterodyne radio receiver* (*5 min*)

A10 (*a*) Second-channel selectivity.
(*b*) Intermediate-frequency (IF) gain and stability.
(*c*) Adjacent-channel selectivity.
(*d*) The IF should lay outside the tuning range of the receiver to prevent instability.

Q11 (*a*) *Sketch and label a block diagram of a simple superheterodyne receiver.*
(*b*) *If the receiver is required to cover the medium-frequency band 200–500 m, and the intermediate frequency* (*IF*) *is to be 465 kHz, calculate the maximum and minimum frequency of the local oscillator.* (*10 min*)

A11 (*a*) The sketch shows the block diagram of a superheterodyne receiver.


f
465 kHz
RADIO-FREQUENCY AMPLIFIER
FREQUENCY CHANGER OR MIXER
INTERMEDIATE AMPLIFIER
DETECTOR
AUDIO-FREQUENCY AMPLIFIER
LOCAL OSCILLATOR
f + 465 kHz

(*b*) The wavelength in metres is given by

$$\lambda = \frac{c}{f},$$

where c is the velocity of light (m/s), and f is the frequency (Hz).

Thus the wavelength of 200 m corresponds to a frequency of

$$\frac{3 \times 10^8}{200}\,\text{Hz} = 1500\,\text{kHz},$$

and the wavelength of 500 m corresponds to a frequency of

$$\frac{3 \times 10^8}{500}\,\text{Hz} = 600\,\text{kHz}.$$

Therefore, the maximum local oscillator frequency

$$= 1500 + 465 = \underline{1965\,\text{kHz},}$$

and the minimum local oscillator frequency

$$= \ 600 + 465 = \underline{1065\,\text{kHz}.}$$

[*Tutorial note:* The velocity of radio waves in free space is constant and equal to the velocity of light, *c*.]

Q12 State THREE *advantages and* THREE *disadvantages of the superheterodyne receiver as compared to the tuned-radio-frequency (TRF) receiver.* *(8 min)*

A12 Advantages

(*a*) Most amplification, before the detector, is at a fixed intermediate frequency (IF).

(*b*) Normally, only two tuned circuits (local oscillator and RF amplifier) have to be ganged together in a superheterodyne receiver.

(*c*) Automatic gain control can easily be obtained.

Disadvantages

(*a*) Frequencies near the IF cannot be tuned.

(*b*) Heterodyne whistles are produced at harmonics of the oscillator.

(*c*) Image- or second-channel interference can occur.

Q13 Briefly explain the term 'second-channel (or image-frequency) interference', and how this could be reduced in superheterodyne receivers. *(8 min)*

A13 There is always another frequency that will produce the intermediate frequency (IF), irrespective of the frequency a superheterodyne receiver is tuned to. This other frequency is termed the *image frequency.* It can be shown that

$$f_{\text{im}} = f_s + 2f_{\text{if}},$$

where f_{im} = image frequency,
f_s = signal frequency, and
f_{if} = intermediate frequency.

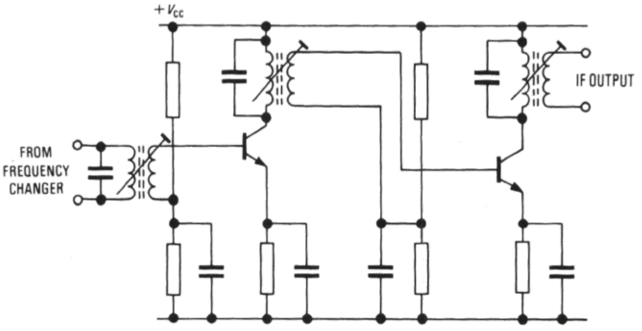
For example, for $f_s = 600$ kHz and $f_{\text{if}} = 465$ kHz, oscillator frequency = 600 + 465 = 1065 kHz.

For oscillator frequency = 1065 kHz and $f_{\text{if}} = 465$ kHz, $f_{\text{im}} = 1530$ kHz.

This image frequency produces an interference signal and, since it is at the IF, it cannot be rejected by the IF amplifier. Therefore, the radio-frequency (RF) stage must include a resonant circuit with sufficient selectivity to reject the image signal.

Q14 Draw a simple circuit diagram of an intermediate-frequency (IF) amplifier and briefly explain its main features. *(12 min)*

A14



The circuit can be regarded as cascaded amplifiers. The only difference is that the transformers are tuned to the IF. Correct source and load impedances must be used, otherwise the circuit may become unstable. The circuits are pre-tuned during manufacture and normally no attention is required.

Q15 The diagram shown in Fig. 1 is of a basic transistor modulation circuit

(*a*) *Identify the input/output signals at points X, Y and Z.*

(*b*) *Briefly explain the operation of the circuit.* *(5 min)*

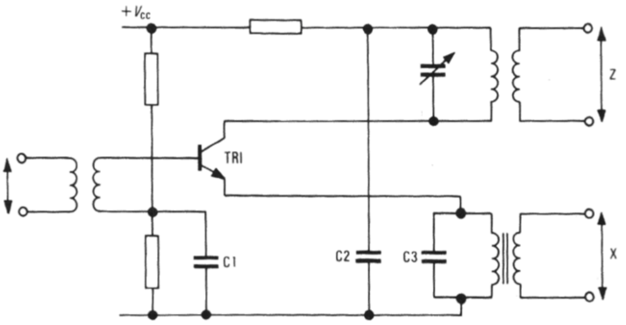


Fig. 1

A15 (*a*) Signal at X—modulation input.
Signal at Y—radio-frequency (RF) input.
Signal at Z—modulated output.

(*b*) The RF carrier voltage and modulation voltage are applied at the base and emitter of transistor TR1, respectively. The gain varies in sympathy with the modulating voltage, and thus amplitude-modulated RF output is obtained at the collector of transistor TR1. Capacitors, C1, C2 and C3 provide RF paths.

Q16 (*a*) *Briefly explain the terms:*

(*i*) *low-level modulation, and*
(*ii*) *high-level modulation,*

as applied to amplitude-modulation transmitters.

(*b*) *Sketch and label a block diagram of a simple high-level amplitude-modulation transmitter; indicate the class of operation normally used in both the radio-frequency (RF) and audio-frequency (AF) stages.*

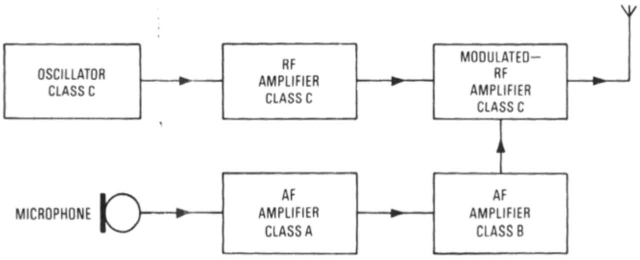
(*c*) *State* ONE *advantage and* ONE *disadvantage of a high-level amplitude-modulation transmitter.* *(10 min)*

A16 (*a*) (*i*) In low-level modulation, modulation takes place prior to the final amplifying stage.

(*ii*) In high-level modulation, modulation takes place at the final amplifying stage.

(*b*) The sketch shows the high-level amplitude-modulation transmitter.

BTEC: RADIO II *(continued)*



(*c*) **Advantage**
High-efficiency class-C amplifiers can be used throughout the high-frequency part of the transmitter. Therefore, particularly for high-power transmitters, high-level modulation is more economical.

Disadvantage
It is not easy economically to generate the high audio-frequency (AF) power required to modulate the output stage.

Q17 Briefly explain the need for frequency multiplication in a radio transmitter, and outline a way in which it can be achieved. *(8 min)*

A17 Often the final radiation frequency is different from the highly-stable low frequency of the oscillator. The oscillator frequency must therefore be multiplied to bring it to the final value.

A transistor with an LC tuned circuit at its collector, operating in class C in order to produce a collector current which is rich in harmonics, can be used. The tuned circuit is normally made to resonate at second or third harmonics of the input voltage frequency. Thus, if the collector is tuned to the third harmonic of the input frequency, the circuit multiplies the input frequency by a factor of three. For higher multiplication factors, two or more stages can be used.

Questions and answers contributed by P. R. Das

BTEC: LINES II

The questions in this paper are based on the BTEC's standard unit U81/755. Students are advised to read the notes on p. 1

Q1 Explain the term 'corporate planning'. *(2 min)*

A1 Corporate planning is the process whereby the senior management of a company, endeavour to reduce the gap between the forecasted performance and the actual performance of that company in order to achieve the corporative objectives of the company.

Q2 Define the following parameters of telephone system performance:

(a) quality of maintenance, and
(b) time to clear faults. *(2 min)*

A2 (*a*) Quality of maintenance may be defined as the ratio of all faults reported by customers in a specified period to the average number of telephones in service during that period.

(*b*) Time to clear faults may be defined as the percentage of fault reports that are cleared by the end of the next working day.

Q3 What are the main advantages of automatic telephone systems over manual telephone systems. *(3 min)*

A3 (*a*) Continual service regardless of the presence or level of operating staff.
(*b*) Faster switching times.
(*c*) Not labour intensive.
(*d*) High level of secrecy.
(*e*) The system is not subjected to the inconsistencies of human behaviour.

Q4 A typical telephone transmitter feed current is

(a) 6 mA, (b) 60 mA, or (c) 600 mA

Select correct figure. *($\frac{1}{2}$ min)*

A4 60 mA

Q5 A town having 12 500 households, or tenancies, has a penetration factor of 70%. Determine the number of telephone installations. *(2 min)*

A5

$$\text{Penetration factor} = \frac{\text{number of telephone installations}}{\text{total number of tenancies}}.$$

Thus, the total number of telephone installations

$$= 0{\cdot}7 \times 12\,500,$$
$$= \underline{8750}.$$

Q6 Identify the difficulties in obtaining an accurate forecast. *(4 min)*

A6 There are two types of forecasting: national and local. The difficulties of national forecasting are: unforeseen national and international crises; unforeseen economic, political or technical changes; and unforseen customer resistance.

The difficulties arising from local forecasting are: unforeseen changes in planning and development of the area; unforeseen bankruptcies; closures of leasehold properties; fire or storm damage; and unforeseen customer resistance.

Q7 What is the purpose of a rolling forecast? *(1 min)*

A7 The purpose of a rolling forecast is to provide a regular update of forecast information as the original time coverage of the forecast decreases.

Q8 What is the term used to describe the combination of 'bottom up' and 'top down' forecasting? *($\frac{1}{2}$ min)*

A8 Complementary forecasting.

Q9 The power entering a disturbing channel is 3 mW and the near-end crosstalk of the disturbed channel is 5 µW.

Determine the near-end crosstalk attenuation. *(3 min)*

A9

$$\text{Attenuation} = 10\log_{10}\frac{3 \times 10^{-3}}{5 \times 10^{-6}},$$
$$= 10\log_{10} 600,$$
$$= \underline{28\,\text{dB}}.$$

Q10 Define the term 'cable'. *(2 min)*

A10 A cable is an assembly of wires insulated from one another and enclosed in a common sheath, having some degree of flexibility.

Q11 *Two similar conductors are separated by an air dielectric. As the distance between the two conductors increases, the capacitance between them* INCREASES/DECREASES *and the inductance between them* INCREASES/DECREASES.
Delete the incorrect words. (*1 min*)

A11 Correct words: Decreases . . . Increases.

Q12 *Define the term 'attenuation coefficient' of a transmission line.* (*2 min*)

A12 The attenuation coefficient is the natural logarithm of the ratio of the magnitude of the current at the beginning of a one metre section of an infinite line to the magnitude of the current at the end of that section.

Q13 (*a*) *What is the purpose of staying a pole?*
(*b*) *What forces are a pole subjected to when stayed?* (*3 min*)

A13 (*a*) A pole is stayed to compensate for the bending stresses it is subjected to due the pull of line wires and cables and wind pressure.
(*b*) A pole is subjected to forces caused by the weight of the wires, the tension of the stay and the compressive force due to the weight of the wires and the stay tension.

Q14 *The pull on an unstayed pole is given as 350 N. If the effective height of the pole if 6 m, determine the bending moment of the pole.* (*2 min*)

A14

$$\text{Bending Moment} = 350 \times 6,$$
$$= \underline{2100\,\text{N m}}.$$

Q15 *List the environmental factors which affect the tension of line wires.* (*1 min*)

A15 Wind, ice and temperature.

Q16 *For a given product, what are the main factors governing the choice of material to be used?* (*2 min*)

A16 (*a*) The cost of the material.
(*b*) The availability of the material.
(*c*) The suitability of the material for the required product.
(*d*) The ease with which the material can be used during the manufacturing process.

Q17 *What material(s) is/are replacing copper conductors in cables?* (*2 min*)

A17 In some instances aluminium is replacing copper in cable conductors; a material replacing both these metals is glass which is used in fibre form in telephone cables.

Q18 *Describe the characteristics of concrete.* (*2 min*)

A18 Concrete is a mixture of cement, sand and aggregate, with water. It has excellent compressive strength and durability and has the ability to bond strongly to other materials. The ratio of sand, cement and aggregate determines the strength of the material.

Q19 *What are the main activities of line-plant planning?* (*2 min*)

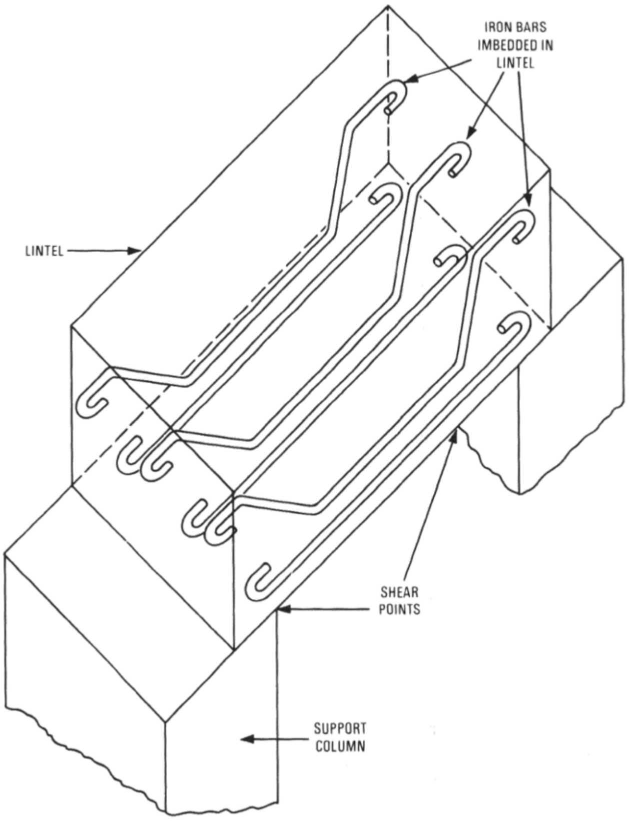
A19 The main activities are anticipating demand, producing a basic project plan, doing preliminary costing, surveying the site, producing works specifications and estimates, carrying out final costing and obtaining authorisation.

Q20 *What is the reference frequency used in the measurement of local line transmission loss?* ($\frac{1}{2}$ *min*)

A20 1600 Hz.

Q21 *Briefly describe, with the aid of a diagram, a typical concrete lintel.* (*6 min*)

A21 Concrete lintels are used as load bearing beams over doorways, windows, hatchways and so on. Although the concrete has very good compressive strength it has very poor tensile strength. Thus a load-bearing lintel, without reinforcement, will shear at the point where the lintel's weight is supported. To counteract the shearing, iron bars are imbedded in the lintel during manufacture. These bond tightly to the concrete with the result that the lintel displays good compressive and tensile strength. The sketch shows a typical arrangement.



Q22 *The following refer to Fig. 1.*
(*a*) *What type of diagram system is being displayed?*
(*b*) *Describe the route indicated by the double-width line.* (*4 min*)

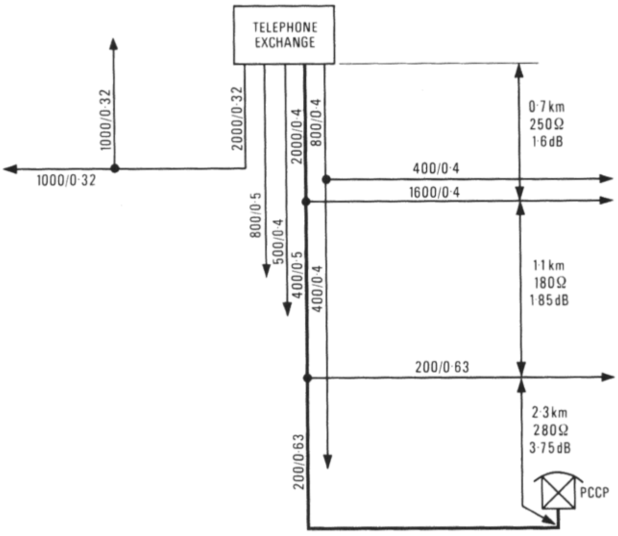


Fig. 1

A22 (*a*) The system displayed is a straight line diagram.
(*b*) From the exchange to the first junction, the cable being used has 2000 pairs, with conductors having a diameter of 0·4 mm. Thereafter a 400-pair cable with conductors of 0·5 mm is being used up to the next junction. The final cable has 200 pairs having 0·63 mm diameter conductors. This cable terminates on a primary cross-connecting point (PCCP).

The overall length of the route is 4·1 km, the overall loop resistance is 710 Ω and the total transmission loss is 7·2 dB. Thus the furthest subscriber served from that PCCP must be, in terms of losses and resistance, no more than 2·8 dB and 290 Ω, respectively, from the PCCP.

Q23 What are the items which make up the total cost of a project? *($1\frac{1}{2}$ min)*

A23 The annual interest charges, the annual depreciation of equipment, the annual maintenance costs and the operating costs.

Q24 During the course of a works project, the work load varies due to the type of work being carried out at various times during the execution of the project. What difficulties may arise due to this fluctuation in work load? *(2 min)*

A24 Having sufficient staff to meet the peak work load periods may result in overstaffing levels at other times during the project. On the other hand, having insufficient staff to meet the peak work-load periods may result in completion dates not being achieved.

Q25 An estimate of a project will identify three main factors, list these factors.

A25 (*a*) Cost of the project.
(*b*) Labour required for the project.
(*c*) Materials required for the project.

Q26 State the typical contents of a written progress report on a works project. *(3 min)*

A26 A progress report should state at the outset,

(*a*) the period of time covered by the report,
(*b*) the date and time of submission, and
(*c*) the name of the person submitting the report.

Thereafter, the manpower expended and materials used should be stated. Any problems which caused departures from, or delays to, the project plan should be included in the report and the departures from the plan detailed.

Q27 Why is 'work measurement' desirable? *(2 min)*

A27 The results of work measurements are an aid to planners in estimating completion times of tasks. The results may also be used to compare work performance or productivity.

Q28 Twenty-four poles are erected by ten men in five hours. If each pole is worth one-third of a work unit and one work unit equals three man-hours, determine

(a) the performance of the workforce, and
(b) the productivity of the workforce. *(3 min)*

A28 (*a*)

$$\text{Performance} = \frac{\text{work done}}{\text{manhours}},$$

$$= \frac{24 \times \frac{1}{3}}{10 \times 5},$$

$$= \underline{0{\cdot}16 \text{ work unit per manhour.}}$$

(*b*)

$$\text{Productivity} = \frac{\text{end product}}{\text{manhours}},$$

$$= \frac{24}{10 \times 5},$$

$$= \underline{0{\cdot}48 \text{ poles per manhour.}}$$

Q29 What type of chart is displayed in Fig. 2. Plot the relevant information. *(3 min)*

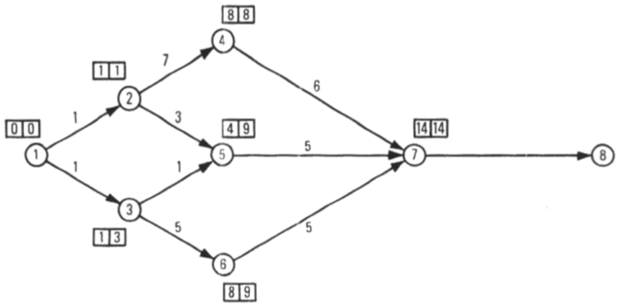
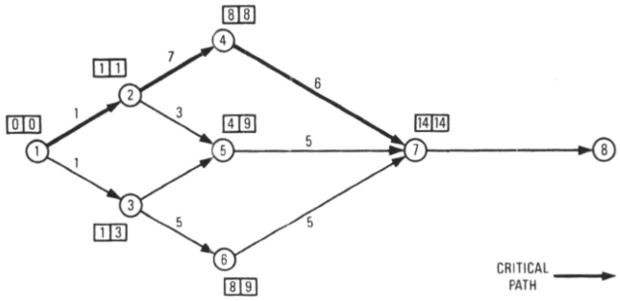


Fig. 2

A29 The chart displayed is a *critical path analysis* (CPA) chart.
The relevant information is the critical path which is shown in the sketch.



Q30 What factors influence project performance? *(5 min)*

A30 Records are kept of the times taken for normal work projects, so that planners can fairly accurately estimate times for normal works activities. In these cases, delays occur only because of unforeseen events such as accidents, strikes and so on. Some projects, however, do not have normal activities; for example, research and development projects. These projects will have activities which are not standard and therefore no standard times are available for assessment purposes. Planners must then rely on the experience of the workforce in estimating target times. The times quoted by the workforce are very often considerably different to the actual times taken for completion thus influencing project performance.

Q31 What types of maintenance systems are used on cables? *(1 min)*

A31 Corrective and preventive maintenance.

Q32 What fault conditions may arise as a result of low insulation between the conductors of a telephone cable pair? *(2 min)*

A32 (*a*) Noisy line.
(*b*) Permanent dial tone.
(*c*) Permanent engaged tone.
(*d*) Dialling errors.

Q33 Why are meggers used in insulation measurements? *(2 min)*

A33 To measure the resistance between any two conductors requires a flow of current between them. Standard ohmmeters provide a voltage which is generally incapable of driving a current through the very high resistance encountered when measuring insulation resistance. Meggers are capable of providing a constant voltage of 500 V or more, thus providing a current flow of sufficient amplitude for measurement purposes.

Q34 The loop resistance of an 18 km line is 990 Ω. During a Varley test for an earth fault, the variable resistor registers 290 Ω using equal ratio arms. Assuming the faulty and good wires have equal resistances, determine the distance between the test set and the fault. *(3 min)*

A34

$$\text{Distance to fault} = \left(1 - \frac{\text{Varley reading}}{\text{loop resistance}}\right) \times 18\ \text{km},$$

$$= \left(1 - \frac{290}{990}\right) \times 18,$$

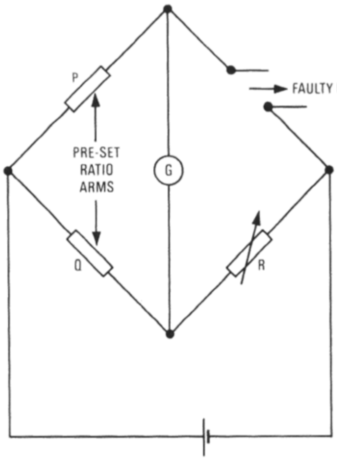
$$= (1 - 0{\cdot}293) \times 18,$$

$$= \underline{12{\cdot}73\,\text{km.}}$$

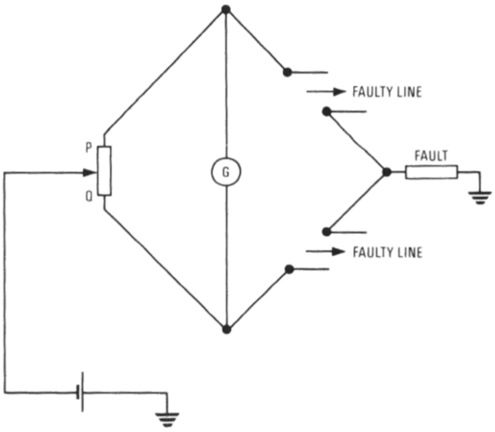
Q35 Describe, with the aid of basic circuit diagrams, the basic difference in measurement techniques between the Varley and Murray testing systems. *(8 min)*

A35 The Varley and Murray systems are based on the Wheatstone Bridge principle. However, in the Varley system the ratio arms are pre-set and a variable resistor in a third arm used to balance the circuit, the fourth arm being representative of the line fault condition. In the Murray system a slide wire is used to vary the ratio arms in order to balance the bridge, the third and fourth arms being representative of the fault condition.

The principles are shown in the sketches.



BASIC CIRCUIT FOR VARLEY TEST



BASIC CIRCUIT FOR MURRAY TEST

Q36 State the advantages of pressurising cables. *(3 min)*

A36 (*a*) A higher standard of insulation resistance is achieved.

(*b*) Internal pressure provides protection to the cable core against the ingress of water.

(*c*) Cable sheath faults are immediately apparent.

(*d*) Cable sheath faults may be located and repaired before electrical faults occur.

(*e*) Improved public image due to reduction of cable faults which affect the electrical performance of the telephone system.

Q37 In a DC measurement test the following cable test data was obtained from a 4 km cable under test.

Absolute single-wire resistance $= 110\,\Omega$.
Absolute insulation resistance $= 170\,\text{k}\Omega$.
Absolute inductance $= 2\,\text{mH}$.
Absolute capacitance $= 0{\cdot}12\,\mu\text{F}$.

Determine the primary coefficients per unit length. *(5 min)*

A37 Absolute loop resistance $= 2 \times 110\,\Omega$,
$= 220\,\Omega$.

Therefore, the loop resistance/kilometre loop $= \dfrac{220}{4}$,

$= \underline{55\,\Omega.}$

Absolute insulation resistance/kilometre $= 170 \times 4\,\text{k}\Omega$,

$= 0{\cdot}68\,\text{M}\Omega$.

Therefore, conductance $= \dfrac{1}{0{\cdot}68 \times 10^{6}}$,

$= 1{\cdot}47 \times 10^{-6}\,\text{S}$,

and conductance per kilometre $= \dfrac{1{\cdot}47 \times 10^{-6}}{4}$,

$= \underline{0{\cdot}367 \times 10^{-6}\,\text{S.}}$

Inductance $= 2\,\text{mH}$.

Therefore inductance per kilometre $= \dfrac{2}{4}$,

$= \underline{0{\cdot}5\,\text{mH.}}$

Capacitance $= 0{\cdot}12\,\mu\text{F}$.

Therefore capacitance per kilometre $= \dfrac{0{\cdot}12}{4}$,

$= \underline{0{\cdot}03\,\mu\text{F.}}$

Q38 Why is it necessary to minimise the forces imposed on a cable when the cable is being drawn into a duct? *(2 min)*

A38 Too much force may result in the cable stretching or becoming chaffed. Also adjacent cables may be damaged.

Q39 What are the effects of wind loading on overhead line wires? *(1½ min)*

A39 An increase in dip and line wire tension occurs; also the direction of the dip changes.

Questions and answers contributed by N. C. Webber

THE·INSTITUTION·OF·BRITISH·TELECOMMUNICATIONS·ENGINEERS
NIL SINE LABORE

British Telecommunications Engineering

Those wishing to subscribe to *British Telecommunications Engineering* can do so by completing the relevant section of the order form below. British Telecom (BT) and British Post Office (BPO) staff should complete the upper section and send it to their local *BTE Journal* agent or, in case of doubts, to the address shown; other subscribers should complete the lower section. A photocopy of this form is acceptable.

SUBSCRIPTION ORDER (BT and BPO STAFF)

To: The Local Agent *(BTE Journal)*, or
British Telecommunications Engineering Journal
(Sales), Post Room,
2–12 Gresham Street, London EC2V 7AG.

Please arrange for me to receive *British Telecommunications Engineering*. I have completed the form opposite authorising deductions from pay to cover the special annual subscription of £2·04.

Date .... Signature ....

Name and initials (in block capitals) .... **Rank** ....

Official address ....

....

....

....

British Telecommunications Engineering: Authority for Deduction from Pay

I, ...

(name in full, surname first in block capitals), authorise the deduction from my salary or wages, until further notice, of the sum of 17p per month/4p per week for payment to the Managing Editor, *British Telecommunications Engineering*, on my behalf.

Date .... Signature ....

Official address ....

....

Rank .... **Pay No.** ....

Area/Dept. ....

Pay group reference ....

YEARLY SUBSCRIPTION ORDER (NON-BT/BPO STAFF)

To: *British Telecommunications Engineering Journal*
(Sales), Post Room,
2–12 Gresham Street, London EC2V 7AG.

Please supply 4 quarterly issues of *British Telecommunications Engineering*. I enclose a cheque/postal order for the sum of £6·00 (Canada and the USA: $10) to cover the yearly subscription.

(Cheques and postal orders, payable to '**BTE Journal**', should be crossed '& Co.' and enclosed with the order. Cash should not be sent through the post.)

Name ....

Address ....

....

....

Please state with which issue you wish your subscription to commence (April, July, October or January) ....

Published by *British Telecommunications Engineering Journal*, 2–12 Gresham Street, London EC2V 7AG
and printed in Great Britain by Unwin Brothers Limited, Old Woking, Surrey